1(a). DNA is a nucleic acid. DNA is found in all living cells.

Read these statements about DNA.

Put ticks (✓) in the boxes next to the **two** correct statements.

DNA is made from four different nucleotides.	☐
Half the nucleotides have a common sugar.	☐
DNA is made from a copy of RNA.	☐
Half the nucleotides have a phosphate group.	☐
DNA is a polymer.	☐

[2]

(b). RNA is another type of nucleic acid. It is involved in protein synthesis.

The table shows the nucleotide sequence in RNA that codes for different amino acids in proteins.

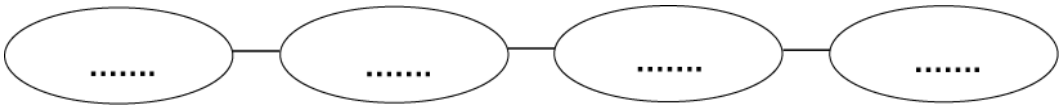
Amino acid	Amino acid abbreviation	Nucleotide sequence
glutamic acid	glu	G A G
leucine	leu	C U G
threonine	thr	A C G
tyrosine	tyr	U A C

Look at the nucleotide sequence in a section of RNA sequence.

G A C U G G A G U A C A C G C C

Write down the sequence of amino acids that this section of RNA codes for.

Use the abbreviation for each amino acid.



[1]

(c). A mutation occurs in the RNA sequence. The nucleotide sequence that results is:

G A C U G U A G U A C A C G C C

Suggest the effect on the production of a protein.

---

[4]

2. To confirm that a female is pregnant a pregnancy test will be done. This test uses monoclonal antibodies.

(i) Describe how monoclonal antibodies are produced.

---

[3]

(ii) Antibodies are proteins.

The statements below describe protein synthesis.

A The mRNA travels to a ribosome in the cytoplasm.

B A copy of the gene is made from messenger RNA.

C The ribosome joins the amino acids together in the correct order.

D The gene that codes for the protein is found in the DNA.

Put the statements in the correct order.

--- --- --- ---

[1]

3(a). James Watson and Francis Crick are famous for identifying the structure of DNA. They wrote a scientific paper about DNA in 1953. Before this, scientists had clues about the parts of the DNA molecule.

One of these clues was the relative amounts of the bases – A, T, C and G. Chemical analysis of DNA from a wide variety of cells showed that:
Total number of A bases and G bases = Total number of T bases and C bases.

What conclusion could early scientists have made from this analysis?

---

[2]

(b). DNA structure is important in the production of proteins. DNA analysis allows scientists to group organisms based on similarities in their DNA.

Complete the sentences below.

A _____ of bases is required to code for an amino acid.

The properties of the protein made depend on the _____ of the amino acids.

Grouping organisms according to similarities in their DNA or physical characteristics is called

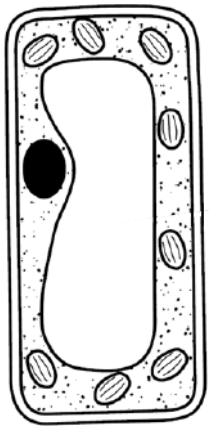
---

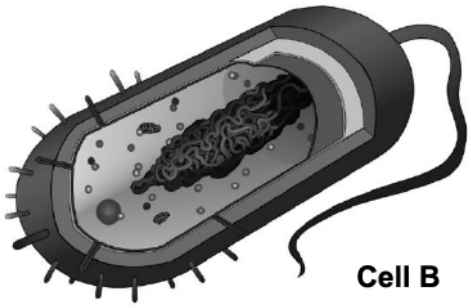
[3]

4. Cells of living organisms carry out their functions in a variety of ways.

Cell A and **Cell B** are cells from different types of living organism.

Cell A





Cell B

Explain one **similarity** and one **difference** in the genetic material of the two cells.

Similarity	Difference

[2]

5.

(i) A group of students decide to look at human red blood cells and human egg cells using a light microscope.

Name a structure that would be visible in the human egg cell but **not** in the human red blood cell.

_____ **[1]**

(ii) A human egg cell is approximately 10^2 μm in diameter.

A human red blood cell is approximately 10 μm in diameter.

How many times larger is an egg cell compared to a red blood cell?

_____ X larger **[1]**

(iii) Suggest an advantage of both cells being the size they are.

Human egg cell _____

_____

Red blood cell _____

_____ **[2]**

6(a). Read the article about classification.

Scientists use amino acid sequences to classify living things.

Scientists know that DNA codes for amino acids. They also know that amino acids are joined together to make proteins. By examining the sequence of amino acids in the same proteins in different animals, scientists can work out how closely related the animals are. The more similar the sequence, the more closely related organisms are. This technique is now being used to classify organisms in a completely new and more reliable way.

The table shows the sequence for eleven amino acids in humans and four other organisms.

Organism	Sequence of amino acids in a protein											Number of differences
	1	2	3	4	5	6	7	8	9	10	11	
Human	Gly	Asp	Val	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Ile	
A	Gly	Asp	Ile	Glu	Lys	Gly	Lys	Lys	Val	Phe	Val	3
B	Gly	Asp	Val	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Val	1
C	Gly	Asp	Ile	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Val	2
D	Gly	Asn	Pro	Asp	Ala	Gly	Ala	Lys	Leu	Phe	Lys	7

Look at organisms **A, B C and D**. The shaded boxes show where the sequence of amino acids differs from that found in humans.

The column on the right shows the total number of these differences.

Describe and explain the conclusions that can be made from the data in the table.

Use the information in the article to help you.

---

[3]

(b). Suggest how the data could be improved to make scientists more confident in their conclusions.

---

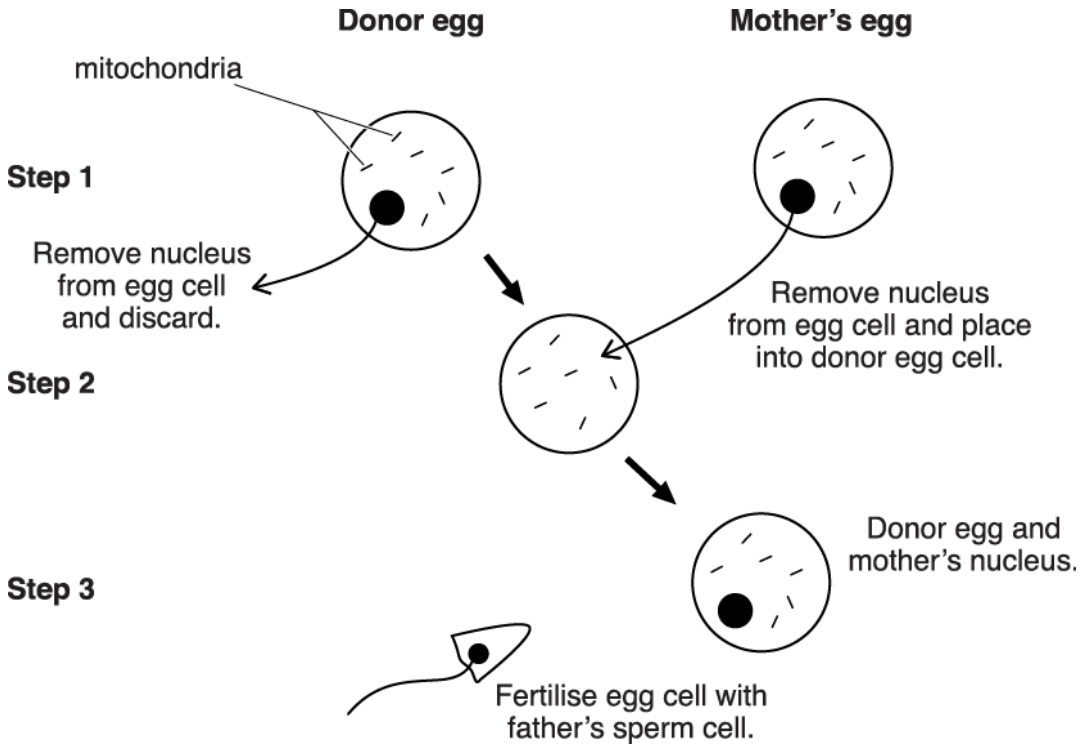
[2]

7(a). Scientists use cell structures from three people to make a baby:

- the nucleus from a mother's egg cell
- the nucleus from a father's sperm cell
- the mitochondria from a donor's egg cell.

This technique will help prevent some genetic diseases caused by faulty mitochondria.

The diagram below shows how the process will be done.



Step 4 Fertilised egg cell is then placed in the mother's uterus.

Mitochondria contain 37 genes.

The nucleus of a fertilised egg cell contains 40 000 genes.

What percentage of its genes does the fertilised egg cell receive from the donor?

Give your answer to 2 decimal places.

Show your working.

_____ % [2]

(b). Most of the baby's physical characteristics will be inherited from its father and mother.

Suggest why.

_____

_____

_____ [1]

(c). Genes code for proteins.

What type of protein could the genes in the mitochondria code for?

_____ [1]

(d). Babies created by this new technique will contain the DNA from 3 different individuals.

Some people do not agree with the use of this new technique.

Suggest and explain why.

_____

_____

_____

_____

_____ [3]

(e). Approximately 1 in 200 children have faulty mitochondria.

1 in 6500 children will have serious diseases as a result.

Do you think this justifies the development of this new technique?

Explain your answer.

---

[2]

(f). The DNA in the mitochondria of people affected by mitochondrial disease contains mutations.

A mutation is a change in the base sequence of the DNA.

Explain how these mutations can cause problems.

---

[2]

8(a). Our genes and chromosomes contain genetic information.

Write a word in the gap to complete each sentence.

Genes are instructions for a cell that describe how to make _____.

Genes are sections of long molecules of _____ that make up chromosomes.

The combination of alleles an organism has is called its _____.

The observable characteristics of an organism are called its _____.

[2]

(b). Human body cells usually contain 23 pairs of chromosomes.

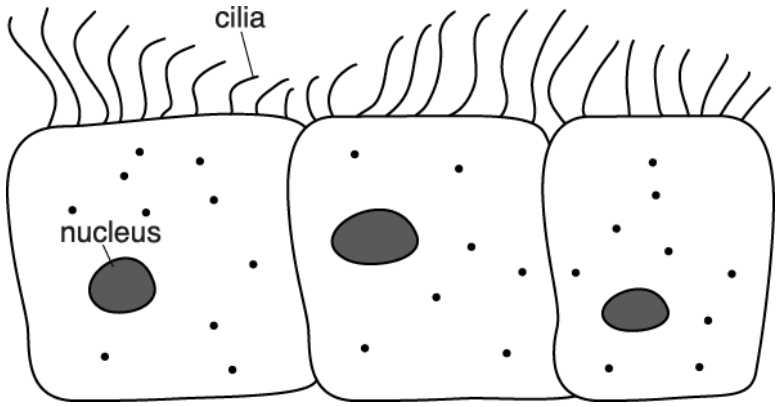
In males and females, 22 of these pairs of chromosomes look the same.

Write down the name of the pair of chromosomes that look different in males and females.

_____.

[1]

9. Some specialised cells have cilia.



Cilia are made from proteins.

Cilia are only made by certain cells.

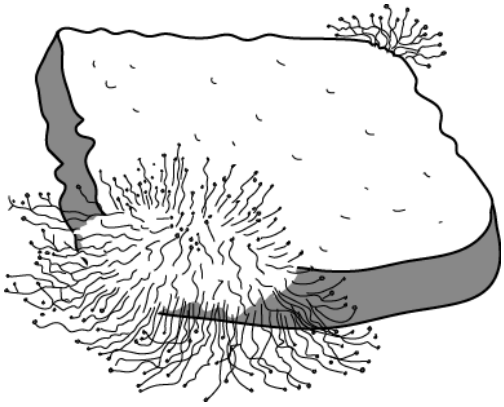
Explain how the proteins in cilia are made and what prevents these proteins being made by all cells.

The quality of written communication will be assessed in your answer.

[6]

10. Moulds are living things that can grow on bread.

They make and release a digestive enzyme onto the bread.



Describe how the DNA in the mould codes for the enzyme and how the enzyme is made.

The quality of written communication will be assessed in your answer.

[6]

11(a) This question is about DNA and genes.

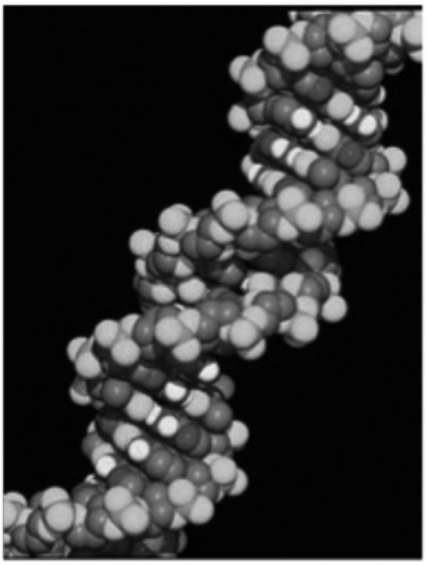
.

DNA is a double helix.

The double helix is divided into genes along its length.

The two strands are held together by bonds between pairs of bases.

The bases always pair up in the same way.



Genes code for proteins.

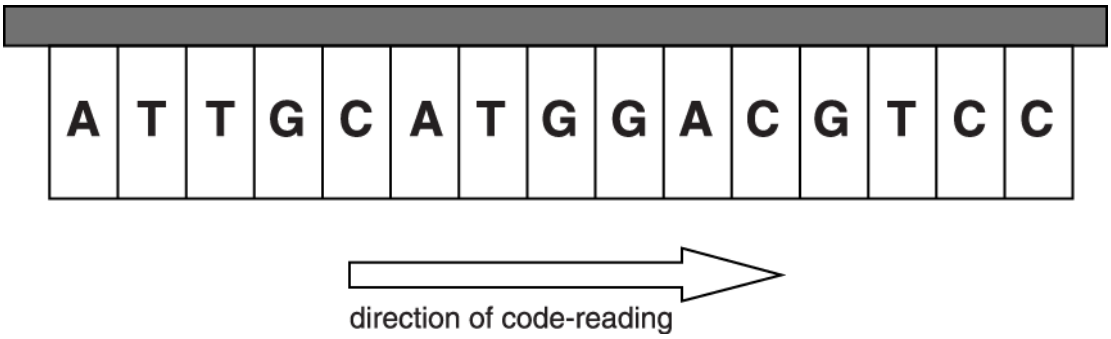
The bases work in groups of three, called the **triplet code**.

An example of how the bases code for the different amino acids in the protein produced is shown in the tables.

DNA triplet code	Amino acid
ATT	1
TGG	2
CCT	3
AGG	4
GCA	5
GGA	6
TGC	7
TCG	8

DNA triplet code	Amino acid
ATC	9
GGT	10
TCC	11
AGC	12
TTA	13
TAC	14
ACG	15
GAC	16

Look at one strand of bases from part of a gene.



What is the order of amino acids found in the protein coded by this gene?

Write the correct amino acids, 1 to 16, in each box.

One has been done for you.

		2		

[2]

(b). A copy of a gene must leave the nucleus and enter the cytoplasm for protein synthesis.

What is the name of this gene copy?

answer _____ [1]

12.

(i) Plants need to make amino acids.

Which **two** molecules do plants use to make amino acids?

Put a tick (✓) in the boxes next to the **two** correct answers.

Cellulose ☐

Glucose ☐

Nitrate ☐

Protein ☐

Starch ☐

[2]

(ii) Which type of large molecule are amino acids used to make?

Put a tick (✓) in the box next to the correct answer.

Cellulose	☐
Glucose	☐
Nitrate	☐
Protein	☐
Starch	☐

[1]

[Total: 15]

13(a). Amaya reads an article in a magazine which explains that genes code for the production of a taste receptor on the tongue.

Taste receptors are proteins.

Complete the sentences to describe how a protein is made.

Use words from the list.

Each word can be used once, more than once, or not at all.

amino acids bases DNA fatty acids gene

genetic variant mitochondrion mRNA protein ribosome

A copy of the ..... is made from ..... .

This molecule travels to a ..... in the cytoplasm.

Here ..... are joined together to form a protein.

A mutation would create a ..... and therefore a different receptor.

[4]

(b). Scientists think that a mutation created the type of receptor that allows someone to taste a bitter substance.

Explain how a mutation could affect the structure of the receptor protein.

---

[2]

14. Nina is learning about substances absorbed by plants. She finds out that plants absorb nitrate ions from the soil.

Explain why nitrate ions are essential for plant growth and survival.

--- [2]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		✓ DNA is made from four different nucleotides ✓ DNA is a polymer	2	If more than two boxes are ticked, do not award the mark even if the correct box is also ticked
	b		Correct sequence of amino acids – leu, glu, tyr, thr ✓	1	**ALLOW** leucine, glutamine, tyrosine, threonine
	c		**Any four from** Mutation is a substitution ✓ Result could be no change / new triplet might still code for same amino acid ✓ Result might be that the new triplet code for a different amino acid ✓ This might cause the protein not to function correctly / not to form ✓ Might affect a characteristic / the phenotype ✓	4	
			Total	**7**	
2		i	Antigen is injected into the animal ✓ The antibody producing cells are taken from the animal ✓ The cells producing the correct antibody are then Selected and cultured ✓	3	All three stages needed for three marks
		ii	D B A C	1	
			Total	**4**	
3	a		A pairs with T or A pairs with C ✓ G pairs with T or G pairs with C ✓	2	**DO NOT ALLOW** A pairs with T or G pairs with C alone
	b		Triplet ✓ Order / sequence ✓ Classification ✓	3	
			Total	**5**	
4			*Similarity:* made from DNA / nucleic acid ✓ *Difference:* in the nucleus in the animal cell and in a loop in the bacteria ✓	2	
			Total	**2**	
5		i	Nucleus ✓	1	
		ii	10 ✓	1	

Question			Answer/Indicative content	Marks	Guidance
		iii	Only need one egg cell / makes it easier for sperm to find egg cell ✓ RBC needs to move through small spaces / need lots of RBCs ✓	2	ALLOW idea of food storage in egg cell
			Total	4	
6	a		Any three from B most similar to humans ✓ D most different to humans ✓ Idea of showing how closely related different organisms are ✓ Reference to different proteins ✓	3	
	b		Longer sequence ✓ Repeat ✓	2	
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
7	a		40,037 / 40,000 + 37; 0.09;	2	 0.09 **must** be expressed to two decimal places. **Examiner's Comments** Given it was a calculation, this was answered relatively poorly with the majority of candidates gaining no marks. Of those who scored, many gave 0.09 as the answer, but with no working or the incorrect working. Many candidates got the answer 0.09 but often by carrying out the calculation (37/40000) × 100, which limited them to one mark. It is important to note that showing working here was essential to gain the second mark, and candidates should always be encouraged to show their working. Some candidates gave the answer to more than two decimal places, or to two significant figures. Many candidates calculated 40000/37.
	b		*any one from:* **majority of / most of / 99.91%** of their genes/chromosomes/genetic information/DNA from the mother and father/parents/sperm and egg/fertilised egg (not the donor); only small percentage of their genes/chromosomes/genetic information/DNA inherited from the donor; idea that most characteristics are coded for by DNA/genes/chromosomes/genetic material **found in the nucleus**;	1	 **ignore** reference to 50% from mother / 50% from father **Examiner's Comments** This question was answered poorly, with candidates not taking time to understand what was being asked. Many candidates focused on half of genes/23 chromosomes originating from each parent, without credit. Although some candidates had the correct idea that most genes come from the mother and father, they frequently forgot to say 'most', failing to understand what the question was actually asking. Some did say that characteristics are coded for by genes found in the nucleus. Very few made explicit the idea that few genes originated from the donor.

Question			Answer/Indicative content	Marks	Guidance
	c		enzymes	1	**ignore** named proteins / enzymes **accept** structural/structure / functional/function (proteins) **Examiner's Comments** Most candidates did not score on this question, with a surprising number of no response answers. Of those who did score, enzymes was frequently given, with some candidates giving functional as a response and very rarely structural. Some did name specific enzymes or proteins, such as e.g. amylase/keratin and some candidates wrote 'hair', but these were not worthy of credit. Many also wrote 'amino acids', but again this was not worthy of credit. Given enzymes are a type of protein, the proportion of wrong answers was surprising.

Question			Answer/Indicative content	Marks	Guidance
	d		*any three from any category:* *Consideration of consequences. Examples include:* not enough known (about the impact); DNA in the mitochondria may affect the characteristics of the child / cause complications; may be unsafe / harmful / risky; may cause disability; idea of concerns about where it could lead; likely to be costly / could the money be put to better use; problems caused by having three parents; causes problems for DNA testing; psychological problems; consideration of other consequences; *Consideration of ethics. Examples include:* unethical/morally wrong; is it right to select based on disease/to get rid of genetic disease; child unable to give consent/decide; uncertainty over legal parents/ donor may wish to parent the child / donor is not fully the parent of the children; should only have two parents / people may believe that a child should not have three parents; destruction of an egg cell / nucleus / genetic information / DNA which could have created life; other ethical consideration; *Religious argument. Examples include:* religious reasons / against God's will; other religious argument;	3	**accept** alternative ideas to those on left **ignore** mutations **ignore** 'unnatural' **ignore** reference to embryos **ignore** 'playing God' **Examiner's Comments** Most marks were awarded for simple statements of ethical or religious reasons or problems associated with having three parents. Some candidates talked about the nucleus which could become a life being discarded, although some gave this in the context of an embryo, which gained no credit. 'Playing God' and unnatural were very frequent responses which gained no credit. Centres are advised that these responses do not gain credit, and candidates should be advised against them. Only a small number candidates considered costs, or considered consequences. The candidates that did identify consequences tended to be around the ideas of where it may lead. Very few considered the impact on the child themselves.

Question			Answer/Indicative content	Marks	Guidance
	e		**any two from** (1 in 200 is a) **high** number of children affected; (so) less money will be spent treating children with diseases; (so) prevents faulty mitochondria being passed on to offspring/children; (but) **low number** (seriously) affected / **only** 1 in 6,500 / small chance of being (seriously) affected (so it may be) cheaper to treat those affected (than to develop the new technique); (however) idea that money used for the treatment only benefits few people / one disease / could benefit more patients/other diseases; it is worth it even to save one life / improve the quality of life / health;	2	**ignore** reference to religious and ethical arguments **accept** alternative idea that this is a high number in a whole population **Examiner's Comments** This question frequently scored 1 out of the 2 marks, with a significant number of candidates failing to use the information provided in the question. Many candidates gained credit for stating that the technique would improve quality of life, or save lives. Many candidates identified 1 in 6500 being a low number. Very few candidates discussed the idea of preventing faulty mitochondria being passed on. Some candidates did use both the 1 in 200 and the 1 in 6,500 figures thoughtfully in their answers to score 2 marks. Few candidates referred to it being cheaper to treat those affected than to develop the new technique.

Question			Answer/Indicative content	Marks	Guidance
	f		**any two from** amino acid **sequence** will be different/ the amino acids coded for will be different; no/different/incorrect protein/enzyme produced; protein/enzyme may not function;	2	**ignore** changes to the production/formation of amino acids **Examiner's Comments** Generally the idea that a different or wrong protein would be produced was scored by many candidates. The concept of amino acid sequence being changed seemed not to be so well understood, and rarely scored. There were quite a few references to amino acid *production*, which on its own did not gain credit. Quite a lot of candidates seized on the mutation idea and described how a mutation could affect an individual ranging from various disabilities to cancer, occasionally also talking about incorrect base pairing. The link between a protein being different and a protein not functioning was not often seen, so relatively few candidates scored the final marking point.
			Total	11	
8	a		proteins; DNA; genotype; phenotype	2	four correct = 2 marks two or three correct = 1 mark one correct = 0 marks **accept** enzymes **Examiner's Comments** Many candidates were able to provide at least 2 correct responses for 1 mark.
	b		sex (chromosomes) / XX / XY / X AND Y	1	**do not credit** ‘sex cells / gametes’ / genes **do not credit** ‘X’ alone or ‘Y’ alone **Examiner's Comments** The majority of candidates were able to produce the correct response.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
9			**Level 3 (5–6 marks)** a good explanation of protein synthesis **AND** A good description of cell specialisation Quality of written communication does not impede communication of the science at this level **Level 2 (3–4 marks)** An explanation of protein synthesis **AND** a description of cell specialisation Quality of written communication partly impedes communication of the science at this level **Level 1 (1–2 marks)** an explanation of protein synthesis **OR** a description of cell specialisation Quality of written communication impedes communication of the science at this level **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit	6	This question is targeted at grades up to A* Indicative scientific points may include Protein synthesis • DNA / genetic material is located in the nucleus • the DNA cannot leave the nucleus • the DNA is unzipped / copied • mRNA is formed • mRNA can leave the nucleus • enters the cytoplasm • ribosome involved • gene has a sequence of bases • ref. to triplet code / codon • which corresponds to the order of amino acids • amino acids are joined to form the protein. Cell specialisation • all cells contain the same genes • genes / DNA / mRNA code for proteins • different genes are switched on / switched off • ciliated cells have the gene switched on • genes that are switched on in a cell will produce the protein / cilia • genes that are switched off in a cell will not produce the protein / cilia **Accept** higher level answers Examiner's Comments This question tended to be the lower scoring of three 6 mark questions. However, there were some excellent descriptions of protein synthesis, some responses included transcription and that although all cells have the same DNA only parts of it are read in specialised cells. Unfortunately, some of candidates only got 2 marks as there was no correct mention of cell specialisation. A few candidates got 2

Question			Answer/Indicative content	Marks	Guidance
					marks for a description of cell specialisation without mention of protein synthesis, but these were in the minority. Many candidates defined what specialised and unspecialised cells are e.g. cells may be specialised for a particular function, their structure will allow them to carry this function out, rather than stating whether genes are switched on or off. The most common misconception was to discuss the cell, rather than the gene being switched on/off.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
10			[Level 3] A good description of coding AND enzyme being made. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Incomplete description of coding AND enzyme being made. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Simple description of DNA code OR how enzyme is made Quality of written communication impedes communication of the science at this level. (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to A* Indicative scientific points for coding may include: • DNA contains bases • bases are A T C G • the order of bases (in a gene) is the code for building up amino acids in the correct order • 3 bases needed to code for 1 amino acid • triplet code • DNA unzips • mRNA / codon / a copy (of the gene) is made Indicative scientific points for making an enzyme may include: • mRNA / codon / a copy leaves the nucleus • mRNA / codon / a copy goes to cytoplasm / ribosome • cytoplasm / ribosome where enzyme / protein is made • amino acids are added in the correct sequence • proteins / enzymes are made from amino acids Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments The question was well answered by a significant proportion of the candidates i.e. they were awarded 5 or 6 marks and there were remarkably few no responses. A few candidates gave excellent responses which were restricted to just coding or making points and were therefore limited to Level 1 but these were very much in the minority. Most responses awarded Level 1 marks were simply because of lack of knowledge. Similarly a few candidates gave good answers with several coding or making points but only a single point for

Question			Answer/Indicative content	Marks	Guidance
					the other aspect and were limited to level 2 because of this. One common 'error' seen was the occasional protein/enzyme being formed in the chloroplast. Not many except the very best candidates utilised the '3 bases needed to code for one amino acid' point although several did recognise that proteins/enzymes were made out of amino acids and that this involved a triplet code and some idea of a sequence or order. Some candidates completely misunderstood the question and gave details about how enzymes work (lock-and-key, etc.) but nothing creditworthy. Other common mistakes referred to the triplet code of amino acids or that at the ribosome the amino acids were made or that the bases are amino acids.
			Total	6	
11	a		1, 5, (2), 15, 11	2	4 correct responses = 2 marks 3 correct responses = 1 mark 2 or fewer correct responses = 0 marks Examiner's Comments The vast majority of candidates scored two marks here and seemed confident about interpreting the triplet code. Where marks were lost, it was usually for careless errors.
	b		messenger RNA / mRNA (1)	1	**allow** upper or lower case letters Examiner's Comments A pleasing number of candidates got this answer correct and so many scored a mark here. The most common incorrect response was 'clone'.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
12		i	glucose (1) nitrate (1)	2	**deduct** one mark for each additional tick
		ii	Protein	1	**deduct** one mark for each additional tick
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
13	a		gene ✓ mRNA ✓ ribosome ✓ amino acids ✓ genetic variant ✓	4 (AO 1.1 x 4)	5 correct = 4 marks 4 correct = 3 marks 3 correct = 2 mark 2 correct = 1 mark Examiner's Comments Few candidates gained full marks on this question. The most common errors were seen in the first sentence. Very few candidates realised that it was a copy of the gene which was made from mRNA, many thought it was a copy of the DNA.
	b		(mutation) changes the base sequence in the DNA / order of bases/ triplet codes ✓ this would give rise to a different sequence of amino acids/ a different amino acid is coded for (in the receptor protein made from the gene) ✓	2 (AO 1.1 x 2)	DO NOT ALLOW the idea that triplet bases make different amino acids Examiner's Comments This question was aimed at a high level and was designed to test candidates understanding as to why mutations were problematic to protein structure. It was clear from the answers seen that many candidates did have an idea of how mutations affect structure, but their explanations were a little confused and lacked precision when using key terminology. It was pleasing to see that candidates had been taught how the base sequence could change as a result of a substitution, deletion or addition, unfortunately some candidates did not continue with the explanation to discuss the impact this would then have on the base sequence and consequently lost the first marking point. Many candidates incorrectly referred to the change in base sequence resulting in different amino acids being made.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
14			(nitrate ions are the plant's only source of) nitrogen ✓ to make amino acids/proteins/nitrogenous compounds ✓	2 (AO 1.1 × 2)	ALLOW examples e.g. enzymes / DNA Examiner's Comments This question required candidates to recognise that nitrates were the plant's source of nitrogen and that nitrogen was needed to make amino acids or other nitrogenous compounds.
			Total	2	